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Social determinants of lung cancer incidence in Canada: A 13-year prospective study

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Abstract

Background: The risk of lung cancer has been shown to be related to socioeconomic status (SES). Because the Canadian Cancer Registry does not contain socioeconomic data, the 1991 Canadian Census Cohort was used to study social determinants of lung cancer risk in the general Canadian population.

Data and methods: This study examines incidence rates of lung cancer and histologic subtypes by educational attainment, income and occupation in a broadly representative sample of Canadians aged 25 or older. Data for the 1991 Canadian Census Cohort were analyzed. The cohort comprised 2,734,835 individuals, among whom 215,700 new cancer cases were diagnosed from 1991 through 2003. Age-standardized incidence rates were calculated by age, sex, and SES using the direct method. Rate ratios, rate differences, and excess incidence were also calculated.

Results: An inverse risk between lung cancer incidence and educational attainment, income and occupation emerged among men and women, and a stepped negative gradient in RRs was evident for all SES variables and age groups. If all cohort members had experienced the rate of those with a university degree, lung cancer incidence would have been 56% lower in men and 55% lower in women. If all cohort members had experienced the incidence rate of those in the highest income quintile, incidence would have been 33% lower in men and 25% lower in women. If all cohort members had experienced the rate of those in managerial occupations, incidence would have been 54% lower in men and 44% lower in women.

Interpretation: A negative gradient in lung cancer risk was evident for all SES variables studied.

Keywords: Age-standardized incidence rates, longitudinal study, lung cancer, record linkage, social determinants of health, socioeconomic inequalities

Lung cancer is the most commonly diagnosed cancer and the leading cause of cancer death in Canada, with an estimated 26,100 new cases and 20,500 deaths in 2014.[1] Research consistently shows that lung cancer risk is inversely associated with socioeconomic status (SES).[2-19]

Examining cancer outcomes by SES in Canada is challenging because cancer registration data do not usually contain information on individual-level socioeconomic characteristics.[20] Previous Canadian studies have explored associations between lung cancer and SES using small samples, ecological approaches in which neighbourhood-level markers of SES were attached to cancer data, or surveillance systems that employed case-control designs.[8,12-16] These studies were limited by small sample size, lack of representativeness, and biases associated with exposure and outcome ascertainment.

The recent creation of a large, population-based cohort linking a sample of census respondents to the Canadian Cancer Registry[21] overcomes many of these limitations and offers an opportunity to investigate the role of socioeconomic determinants of lung cancer risk in a large, sample of the Canadian population. It also allows for a better understanding of the etiology of lung cancer through the examination of histologic subtypes across socioeconomic gradients. Using data from the 1991 Canadian Census Cohort, this study quantifies the risk of lung cancer by individual measures of SES (educational attainment, income, and occupation) and examines associations by sex, age, and histologic subtype.

Data and methods

Data sources

The data are from the 1991 Canadian Census Cohort, the largest population-based cohort in Canada.[21,22] Individuals were eligible for the cohort if they were aged 25 or older on June 4, 1991, enumerated by the 1991 Census long-form questionnaire, and successfully linked to a name file (consisting of 1990 and 1991 tax-filers) using standard probabilistic techniques. Exclusions were people living in institutions at baseline (1991), census undercoverage (3.4% of the population, including residents of 78 Indian reserves), and individuals who did not file taxes in either 1990 or 1991. Approximately 2.7 million individuals who completed the long-form questionnaire were successfully linked to the Canadian Cancer Database (from 1969 to 2003), the Canadian Mortality Database (from 1991 to 2006), and a residential postal code file (1984 to 2007) derived from tax-filer data.[21,22]

The cohort contains a rich breadth of demographic and socioeconomic information derived from the 1991 Census long-form questionnaire. Cancer information includes date of diagnosis, age, site, topography, morphology, laterality, and date of death, if applicable.[21] Each cohort member was followed from the day of the 1991 Census (June 4, 1991) to the date of censoring (first diagnosis of lung cancer, the date of emigration, the date of death or the last day of follow-up, whichever came first). Person-days of follow-up were divided by 365.25 to obtain person-years at risk (PYAR).

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Incident cases of lung cancer were identified among the cohort. The outcome variable was the first primary lung cancer. Morphology was coded according to the *International Classification of Diseases for Oncology, 2nd Edition* (ICD-O-2). To better understand lung cancer etiology, individuals who developed a different primary cancer before lung cancer were excluded. Benign and in-situ tumours were also excluded. The analyses were conducted for all lung cancers combined (C34.0, C34.1, C34.2, C34.3, C34.8, C34.9), and separately for the main histological types: adenocarcinoma (ICD-O-2 8140, 8211, 8230-8231, 8250-8260, 8323, 8480-8490, 8550-8560, 8570-8572), squamous-cell carcinoma (ICD-O-2 8050-8076), small-cell carcinoma (ICD-O-2 8040-8045), large-cell including giant-cell, clear-cell and undifferentiated carcinoma (ICD-O-2 8012–8031, 8310), and unspecified carcinoma (ICD-O-2 8010-8011, 8032-8034).

For each cohort member, data were extracted on lung cancer diagnosis, date of diagnosis, date of birth, sex, and three SES variables: 1) highest level of education (less than secondary graduation, secondary graduation including trades certificate, at least some postsecondary short of a bachelor's degree, or university degree); 2) income based on pre-tax low-income cut-offs; and 3) occupation based on the 1990 Standard Occupational Classification. Age-at-baseline, sex, and SES-specific incidence rates by five-year age groups were used to calculate age-standardized incidence rates (ASIRs) using the direct method. The 1991 mid-year population was used as the standard population. Based on methods described in detail elsewhere,[21,22] ASIRs were calculated for each SES indicator separately, and then used to calculate rate ratios (RRs), rate differences (RDs), and corresponding 95% confidence intervals (CIs). Absolute excess incidence was calculated by subtracting the ASIR of those in the highest SES categories (university degree, highest income quintile, managerial occupation) from the ASIR of the total cohort. This difference represents the number of new lung cancer cases per 100,000 PYAR that could have been avoided if all cohort members had experienced the incidence rate of those in the highest SES categories.

Results

From June 4, 1991 to December 31, 2003, 215,700 of the 2,734,835 cohort members were diagnosed with at least one type of cancer. Lung cancer was the most common diagnosis, accounting for 14% of all incident cases and representing 30,075 cohort members (19,220 men and 10,855 women). The average ASIRs of lung cancer among men and women in the cohort were 123 and 69 cases per 100,000 PYAR, respectively. Appendix A shows the characteristics of members of the cohort by sex and SES.

Education

Lung cancer ASIRs showed a stepped gradient by educational attainment, with the highest incidence among men and women with lowest level of education. Compared with men who had a university degree, the ASIR was 1.5 times higher for those with a postsecondary diploma, 2.1 times higher for those with a secondary school diploma, and 2.8 times higher for those with less than a secondary school diploma (Table 1). The gradient was similar for women, among whom the corresponding rate ratios (RRs) were 1.6, 2.1, and 2.7.

When examined by age at baseline, a gradient in lung cancer risk by educational attainment was evident for both sexes at ages 25 to 44, 45 to 64 and 65 to 79, although relative inequalities decreased with age (Table 2). The highest RR was among women aged 25 to 44 with less than secondary education (RR= 4.04), followed by men in the same age/education group (RR = 3.93).

The absolute differences in incidence rates (RD) between those with the lowest versus highest level of education were 95.4 cases per 100,000 PYAR for men and 51.5 cases per 100,000 PYAR for women (Table 1). The absolute education-related excess incidence showed that if all cohort members had experienced the incidence rate of those with a university degree, lung cancer incidence would have been 56% lower among men and 55% lower among women, representing 68.9 and 36.5 fewer new cases per 100,000 PYAR, respectively.

Income

Results also showed a stepped gradient in lung cancer incidence rates among men and women by income quintile. Compared with men in the highest quintile (Q5), the ASIR was 1.25 times higher for those in the second-highest quintile, 1.47 times higher for those in the middle quintile (Q3), 1.75 times higher for those in the second-lowest quintile (Q2), and 2.11 times higher for those in the lowest quintile (Q1). The gradient was similar for women, where RRs for respective comparisons were 1.16, 1.28, 1.40, and 1.81 (Table 1).

A gradient in lung cancer risk was observed for all age groups, although relative inequalities were less clear among people aged 80 or older (Table 2). Lung cancer risk was highest for men and women aged 45 to 64 in the lowest income quintile.

Data on absolute inequalities showed that absolute differences in incidence rates (RD) were 91.1 cases for men and 40.7 cases for women per 100,000 PYAR in the lowest (Q1) versus the highest income quintile (Q5). Income-related absolute incidence excess showed that if all cohort members had experienced the incidence rate of those in the highest quintile, lung cancer incidence would have been 33% lower among men and 25% lower among women, representing 40.9 and 16.7 fewer new cases per 100,000 PYAR, respectively.

Occupation

Lung cancer incidence rates were highest among men and women employed in unskilled jobs or with no occupation, and lowest for those in managerial occupations. Compared with men in managerial occupations, the ASIR was 1.39 times higher for those in professional occupations, 1.65 times higher for those in

Table 1
Age-standardized incidence rates (ASIRs) for lung cancer per 100,000 person-years at risk, rate ratios (RR), and rate differences (RD), by sex and selected socioeconomic status (SES) characteristics, Canadian Census Cohort members aged 25 or older at baseline, Canada, 1991 to 2003

Sex and SES characteristics	Number of cases	ASIR	95% confidence interval		RR	95% confidence interval		RD	95% confidence interval	
			from	to		from	to		from	to
Both sexes										
Educational attainment										
Less than secondary graduation	17,760	113.6	111.9	115.4	2.52	2.38	2.68	68.6	65.5	71.7
Secondary graduation	8,750	88.3	86.5	90.2	1.96	1.85	2.08	43.3	40.1	46.4
At least some postsecondary	2,255	60.0	57.5	62.6	1.33	1.24	1.43	15.0	11.4	18.6
University degree†	1,310	45.0	42.5	47.6	1.00	...	...	0.0	...	...
Income adequacy quintile (Q)										
Q1 (lowest)	7,324	122.2	119.3	125.2	1.82	1.76	1.90	55.2	51.7	58.8
Q2	7,174	105.2	102.6	107.8	1.57	1.51	1.63	38.2	35.0	41.5
Q3	5,686	92.5	90.1	95.0	1.38	1.33	1.44	25.6	22.4	28.7
Q4	5,091	81.0	78.8	83.3	1.21	1.16	1.26	14.1	11.0	17.1
Q5 (highest)†	4,800	67.0	65.0	69.0	1.00	...	...	0.0	...	...
Occupation										
Managerial†	1,072	50.4	46.2	54.9	1.00	...	...	0.0	...	...
Professional	1,494	75.8	70.3	81.7	1.50	1.34	1.69	25.4	18.2	32.6
Skilled/Technical/Supervisory	4,760	80.5	77.7	83.4	1.60	1.46	1.76	30.2	24.9	35.4
Semi-skilled	4,880	88.1	84.6	91.8	1.75	1.59	1.93	37.8	32.1	43.4
Unskilled	2,210	104.6	99.0	110.6	2.08	1.87	2.30	54.3	47.0	61.5
No occupation	15,659	110.8	108.2	113.3	2.20	2.01	2.41	60.4	55.3	65.4
Men										
Educational attainment										
Less than secondary graduation	11,583	149.1	146.3	152.0	2.78	2.59	2.98	95.4	90.9	100.0
Secondary graduation	5,618	114.2	111.1	117.3	2.13	1.98	2.28	60.5	55.8	65.2
At least some postsecondary	1,072	81.8	76.7	87.2	1.52	1.39	1.67	28.1	21.7	34.4
University degree†	946	53.7	50.3	57.4	1.00	...	...	0.0	...	...
Income adequacy quintile (Q)										
Q1 (lowest)	4,155	172.9	167.6	178.3	2.11	2.01	2.22	91.1	84.9	97.3
Q2	4,859	143.3	139.2	147.7	1.75	1.67	1.84	61.6	56.3	66.8
Q3	3,775	120.4	116.6	124.4	1.47	1.4	1.55	38.7	33.7	43.6
Q4	3,320	102.6	99.0	106.3	1.25	1.19	1.32	20.8	16.0	25.6
Q5 (highest)†	3,110	81.8	78.7	84.9	1.00	...	...	0.0	...	...
Occupation										
Managerial†	639	57.1	51.5	63.3	1.00	...	...	0.0	...	...
Professional	1,160	79.4	73.0	86.3	1.39	1.22	1.59	22.3	13.5	31.2
Skilled/Technical/Supervisory	3,461	94.2	90.4	98.3	1.65	1.48	1.85	37.2	30.1	44.3
Semi-skilled	2,884	117.6	111.4	124.1	2.06	1.83	2.31	60.5	51.8	69.2
Unskilled	1,507	130.3	121.7	139.5	2.28	2.02	2.58	73.2	62.6	83.9
No occupation	9,568	174.7	168.3	181.4	3.06	2.74	3.42	117.7	108.9	126.5
Women										
Educational attainment										
Less than secondary graduation	6,177	81.8	79.6	84.0	2.70	2.41	3.03	51.5	47.5	55.5
Secondary graduation	3,132	63.5	61.3	65.7	2.10	1.87	2.36	33.2	29.2	37.2
At least some postsecondary	1,183	49.1	46.3	52.0	1.62	1.43	1.84	18.8	14.5	23.2
University degree†	364	30.3	27.1	33.8	1.00	...	...	0.0	...	...
Income adequacy quintile (Q)										
Q1 (lowest)	3,169	90.7	87.3	94.2	1.81	1.7	1.93	40.7	36.4	44.9
Q2	2,315	69.8	66.9	72.9	1.40	1.31	1.49	19.8	15.9	23.7
Q3	1,911	63.8	61.0	66.8	1.28	1.19	1.36	13.8	10.0	17.6
Q4	1,771	58.0	55.3	60.8	1.16	1.08	1.24	8.0	4.3	11.7
Occupation										
Managerial†	433	37.6	32.0	44.2	1.00	...	...	0.0	...	...
Professional	334	60.9	51.0	72.7	1.62	1.27	2.06	23.2	10.9	35.6
Skilled/Technical/Supervisory	1,299	54.0	50.4	57.8	1.43	1.20	1.71	16.4	9.3	23.5
Semi-skilled	1,996	59.9	56.4	63.5	1.59	1.34	1.89	22.2	15.2	29.3
Unskilled	703	68.5	62.0	75.8	1.82	1.51	2.20	30.9	21.7	40.1
No occupation	6,091	77.8	75.2	80.4	2.07	1.75	2.44	40.2	33.6	46.8

† reference group (RR = 1.00 and RD = 0.0)
... not applicable
Note: Reference population for age-standardization was from 1991 Canadian population.
Source: 1991 Canadian Census Cohort: mortality and cancer follow-up.

skilled, technical or supervisory occupations, 2.06 times higher for those in semi-skilled occupations, 2.28 times higher for those in unskilled occupations, and 3.06 times higher for those without an occupation. A similar, but less steep, gradient was observed for women in skilled, technical or supervisory occupations (RR = 1.43), semi-skilled occupations (RR = 1.59), unskilled occupations (RR = 1.82) or no occupation (RR = 2.07). However, unlike men, incidence was higher among women in professional occupations than among those in the more technical trades.

Relative inequalities in incidence by occupation were most pronounced among men and women aged 25 to 44 and diminished with age (Table 2).

Compared with men in managerial occupations, the absolute differences in lung cancer incidence rates were 117.7 cases per 100,000 PYAR for those without an occupation, and 73.2 cases per 100,000 PYAR for those in unskilled occupations. The corresponding differences for women were 33.6 cases (no occupation) and 21.7 cases (unskilled occupations) per 100,000 PYAR. Occupation-related absolute incidence excess showed that if all cohort members had experienced the incidence rate of those in managerial occupations, lung cancer incidence would have been 54% lower among men and 44% lower among

Table 2
Age-standardized lung cancer incidence rate ratios (RR), by sex, age group and selected socioeconomic status (SES) characteristics, 1991 Canadian Census Cohort members aged 25 or older, Canada, 1991 to 2003

	Ages 25 to 44				Ages 45 to 64				Ages 65 to 79				Age 80 or older			
			95% confidence interval				95% confidence interval				95% confidence interval				95% confidence interval	
Sex and SES characteristics	Number of cases	RR	from	to	Number of cases	RR	from	to	Number of cases	RR	from	to	Number of cases	RR	from	to
Men																
Educational attainment																
Less than secondary graduation	447	3.93	3.12	4.95	5,578	3.22	2.93	3.54	7,439	2.51	2.29	2.75	442	1.65	1.14	2.37
Secondary graduation	564	2.91	2.32	3.65	3,001	2.31	2.10	2.55	2,904	1.96	1.78	2.16	173	1.95	1.33	2.86
At least some postsecondary	141	1.98	1.52	2.59	595	1.67	1.48	1.89	488	1.39	1.22	1.57	26	1.41	0.84	2.38
University degree†	87	1.00	...	...	481	1.00	...	...	499	1.00	...	...	31	1.00	...	...
Income adequacy quintile (Q)																
Q1 (lowest)	227	1.95	1.62	2.35	1,996	2.28	2.14	2.42	2,600	1.63	1.49	1.79	203	1.29	0.99	1.69
Q2	251	1.49	1.24	1.78	1,717	1.74	1.63	1.86	3,428	1.34	1.22	1.48	228	1.20	0.92	1.56
Q3	304	1.38	1.16	1.65	1,922	1.52	1.43	1.62	2,166	1.22	1.10	1.35	101	1.10	0.81	1.48
Q4	240	1.04	0.86	1.25	2,003	1.28	1.20	1.36	1,723	1.16	1.04	1.29	67	1.00	0.72	1.39
Q5 (highest)†	217	1.00	...	...	2,017	1.00	...	...	1,413	1.00	...	...	73	1.00	...	...
Occupation																
Managerial†	137	1.00	...	...	856	1.00	...	...	410	1.00	...	...	X	1.00	...	...
Professional	75	1.67	1.26	2.22	437	1.49	1.33	1.68	243	1.38	1.15	1.67	6	0.87	0.24	3.15
Skilled/Technical/Supervisory	426	2.33	1.82	2.98	2,556	1.97	1.78	2.19	1,227	1.47	1.25	1.72	16	0.88	0.34	2.29
Semi-skilled	367	2.68	2.09	3.44	2,185	2.33	2.10	2.59	942	1.84	1.55	2.17	15	1.71	0.65	4.54
Unskilled	136	3.03	2.28	4.02	1,141	2.70	2.41	3.02	651	2.04	1.71	2.42	7	1.89	0.63	5.71
No occupation	98	5.54	4.09	7.48	2,480	3.57	3.20	3.98	7,857	2.41	2.08	2.79	624	1.73	0.76	3.96
Women																
Educational attainment																
Less than secondary graduation	547	4.04	3.21	5.07	3,009	3.03	2.59	3.55	3,354	2.24	1.88	2.67	285	1.19	0.69	2.03
Secondary graduation	587	2.65	2.11	3.33	1,535	2.25	1.92	2.64	1,349	1.94	1.62	2.32	95	1.21	0.69	2.12
At least some postsecondary	223	1.91	1.48	2.45	627	1.77	1.49	2.11	462	1.54	1.27	1.87	35	0.91	0.49	1.69
University degree†	85	1.00	...	...	177	1.00	...	...	131	1.00	...	...	14	1.00	...	...
Income adequacy quintile (Q)																
Q1 (lowest)	315	1.91	1.61	2.27	1,333	2.03	1.87	2.21	1,768	1.63	1.49	1.79	232	1.17	0.83	1.66
Q2	295	1.49	1.25	1.77	958	1.50	1.37	1.64	1,329	1.34	1.22	1.48	102	0.98	0.67	1.43
Q3	307	1.31	1.10	1.55	1,017	1.42	1.30	1.55	879	1.22	1.10	1.35	31	0.62	0.38	0.99
Q4	294	1.20	1.01	1.43	1,009	1.23	1.12	1.34	710	1.16	1.04	1.29	27	0.67	0.41	1.09
Q5 (highest)†	231	1.00	...	...	1,031	1.00	...	...	610	1.00	...	...	37	1.00	...	...
Occupational rank																
Managerial†	89	1.00	...	...	222	1.00	...	...	74	1.00	...	...	X	...	...	...
Professional	109	2.09	1.58	2.77	296	1.66	1.38	2.00	72	1.40	0.93	2.11	0	...	...	...
Skilled/Technical/Supervisory	322	2.03	1.63	2.52	870	1.60	1.39	1.85	273	1.12	0.81	1.56	7	...	...	...
Semi-skilled	489	2.31	1.87	2.84	1,370	1.78	1.55	2.04	424	1.32	0.96	1.82	X	...	...	...
Unskilled	151	2.76	2.16	3.53	494	1.89	1.62	2.21	161	1.57	1.09	2.24	0	...	...	...
No occupation	282	2.78	2.23	3.47	2096	2.24	1.96	2.55	4,292	1.68	1.25	2.26	419	...	...	...

† reference group (RR = 1.00)
... not applicable
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Note: Reference population for age-standardization was from 1991 Canadian population.
Source: 1991 Canadian Census Cohort: mortality and cancer follow-up

women, representing 65.6 and 29.2 fewer new cases per 100,000 PYAR, respectively.

Histology

A negative gradient in lung cancer risk was apparent for squamous cell carcinoma and small-cell carcinoma for all three SES indicators, but the pattern was less consistent for adenocarcinoma, where a negative gradient was evident only for income and education (Table 3).

The highest RR (3.34) was among individuals diagnosed with squamous cell carcinoma who had less than secondary school graduation, compared with university graduates. A similar but less attenuated risk was observed for income and occupation (Table 3).

Associations were similar for small-cell carcinoma. Individuals with less than secondary school graduation had 2.54 times the risk of small-cell carcinoma compared with university graduates. Individuals in the lowest income quintile had twice the risk compared with those in the highest income quintile, and those without an occupation had 1.53 times the risk of those in professional occupations.

The risk of adenocarcinoma followed a negative gradient by education and income, but no clear pattern emerged for occupation. Numbers for large-cell, and undifferentiated carcinomas and unspecified carcinomas were too small to report.

Discussion

The socioeconomic gradient in lung cancer risk reflects differences in the prevalence of risk factors such as smoking, diet, and environmental and occupational exposure among SES groups.[3,6-10,13,14,18,19] Previous studies have reported an inverse association between SES and lung cancer risk in men,[2-18] but the evidence has been less conclusive for women, with studies finding inverse, positive, or no associations after adjustment for smoking and other confounding variables.[2,4,8,9,19] According to the present analysis, lung cancer risk was inversely associated with education, income, and occupation in both sexes, although associations were weaker for women.

The association between lung cancer risk and SES was strongest for education. In other studies, education has been more frequently associated with disease than other social indicators.[18,23] While the reason for this relationship cannot be determined here, previous research suggests that education is a predictor of income and occupation and a stronger determinant of health behaviours than other socioeconomic indicators, as it is often acquired early in life.[23,24] In addition, education is a more inclusive indicator than income or occupation because it applies to individuals outside the workforce, and does not depend on regional definitions of households and differences in cost of living.[23] The unadjusted RRs for educational inequalities in this study were higher than those previously reported in the United States and Canada (pooled unadjusted RR: 1.84, 95% CI: 1.56-2.19).[19]

While education was the indicator most strongly associated with lung cancer risk in women, among men, risk was highest in the semi-skilled/unskilled and no occupation categories. A larger percentage of female than male cohort members are either not in the labour force or unemployed: 42% versus 28%.[25] Sex-specific differences in lung cancer risk by occupation may reflect the possibility that a larger percentage of women in this cohort were unemployed or not in the labour force, but still lived in relative affluence. Moreover, this finding may imply that exposures to workplace carcinogens are more common among men in semi-skilled and unskilled occupations compared with women, a hypothesis that may be further informed by yet-to-be-published research examining the risk of lung cancer among those in high-risk occupations (welders and miners) using data from the cohort.[26]

Relative inequalities in lung cancer incidence were generally greater in younger age groups, and decreased with age, a finding supported by other longitudinal studies.[19,24] While SES inequalities appeared to persist into old age, they were less pronounced for older age groups. Because the risk of lung cancer rises with age, the impact of SES on risk may be diminished in older age groups. Steeper risk gradients in SES among younger cohort members compared with older members are also compatible with research showing that SES inequalities in smoking prevalence have increased in Canada over the last 60 years despite a steady decline in overall adult smoking prevalence (from more than 40% in 1965 to 16% in 2012).[27,28] This is characteristic of countries that have reached stage IV of the smoking epidemic, where SES differences in smoking appear to be increasing and likely to lead to widening inequalities in lung cancer incidence in the future.[28,29]

Results by histology showed a distinct negative SES gradient in the risk of squamous cell and small-cell carcinoma

What is already known on this subject?

- Studies have consistently shown that the risk of lung cancer is inversely related to socioeconomic status (SES).
- Because the Canadian Cancer Registry does not contain information on individual-level socioeconomic position, lung cancer risk cannot be studied directly by individual measures of SES.
- Recently, a large, representative sample of Canadians aged 25 or older—the 1991 Census Cohort—was linked to 13 years of cancer data.

What does this study add?

- Data from the Canadian Census Cohort showed that that lung cancer risk was inversely associated with education, income and occupation in men and women.
- Education emerged as the SES indicator most strongly associated with lung cancer risk.
- Larger inequalities in lung cancer risk were evident for histologies more strongly associated with smoking.

Table 3
Age-standardized incidence rates (ASIRs) for squamous-cell carcinoma, adenocarcinoma and small-cell carcinoma per 100,000 person years at risk, rate ratios (RR), and rate differences (RD), by selected socioeconomic status (SES) characteristics, 1991 Canadian Census Cohort members aged 25 or older at baseline, Canada, 1991 to 2003

Lung cancer type and SES characteristics	Number of cases	ASIR	95% confidence interval		RR	95% confidence interval		RD	95% confidence interval	
			from	to		from	to		from	to
Squamous-cell carcinoma										
Educational attainment										
Less than secondary graduation	3,799	23.4	22.6	24.2	3.3	2.9	3.9	16.3	15.0	17.6
Secondary graduation	1,530	15.7	15.0	16.5	2.2	1.9	2.6	8.7	7.4	10.0
At least some postsecondary	323	9.0	8.1	10.1	1.3	1.1	1.5	2.0	0.6	3.4
University degree[1]	191	7.0	6.1	8.1	1.0	...	...	0	...	...
Income adequacy quintile (Q)										
Q1 (lowest)	1,471	24.2	23.0	25.6	2.1	1.9	2.3	12.7	11.1	14.2
Q2	1,495	21.4	20.3	22.6	1.9	1.7	2.0	9.8	8.4	11.2
Q3	1,094	17.8	16.8	18.9	1.5	1.4	1.7	6.3	4.9	7.6
Q4	964	15.5	14.5	16.5	1.3	1.2	1.5	4.0	2.7	5.3
Q5 (highest)[1]	819	11.6	10.8	12.4	1.0	...	...	0	...	0
Occupation										
Managerial[1]	143	7.0	5.6	8.7	0.5	0.4	0.6	-7.2	-10	-4.4
Professional	259	14.1	12.0	16.7	1.0	...	...	0	...	...
Skilled/Technical/Supervisory	885	15.5	14.3	16.8	1.1	0.9	1.3	1.3	-1.3	4
Semi-skilled	883	17.0	15.5	18.7	1.2	1.0	1.5	2.9	0	5.7
Unskilled	447	22.7	19.9	25.8	1.6	1.3	2.0	8.5	4.8	12.3
No occupation	3,226	20.6	19.6	21.6	1.5	1.2	1.7	6.5	3.9	9
Adenocarcinoma										
Educational attainment										
Less than secondary graduation	3,864	26.3	25.5	27.2	2.0	1.8	2.2	13.2	11.6	14.8
Secondary graduation	2,295	22.5	21.6	23.4	1.7	1.5	1.9	9.3	7.7	11.0
At least some postsecondary	658	16.9	15.6	18.2	1.3	1.1	1.5	3.7	1.8	5.6
University degree[1]	405	13.2	11.9	14.6	1.0	...	...	0.0	...	...
Income adequacy quintile (Q)										
Q1 (lowest)	1,500	26.8	25.4	28.3	1.4	1.3	1.6	8.3	6.5	10.0
Q2	1,598	24.7	23.4	26	1.3	1.2	1.4	6.1	4.5	7.8
Q3	1,405	22.7	21.5	23.9	1.2	1.1	1.3	4.1	2.6	5.7
Q4	1,340	20.5	19.4	21.7	1.1	1.0	1.2	2.0	0.4	3.5
Q5 (highest)[1]	1,379	18.6	17.6	19.6	1.0	...	...	0.0	...	...
Occupation										
Managerial[1]	372	16.4	14.2	19	0.8	0.7	1.0	-4.1	-7.8	7.0
Professional	435	20.5	17.9	23.5	1.0	...	...	0.0	...	...
Skilled/Technical/Supervisory	1,243	19.5	18.3	20.9	1.0	0.8	1.1		-4.0	15.5
Semi-skilled	1,386	23.3	21.6	25.2	1.1	1.0	1.3	2.8	-0.5	17.0
Unskilled	573	25.5	23	28.3	1.2	1.0	1.5	5.0	1.1	22.7
No occupation	3,213	27	25.7	28.4	1.3	1.1	1.5	6.5	3.4	20.6
Small-cell carcinoma										
Educational attainment										
Less than secondary graduation	2,012	13.2	12.6	13.8	2.5	2.1	3.0	8.0	6.9	9.0
Secondary graduation	998	10	9.4	10.7	1.9	1.6	2.3	4.8	3.8	5.9
At least some postsecondary	217	5.8	5.1	6.7	1.1	0.9	1.4	0.6	-0.5	1.8
University degree[1]	143	5.2	4.4	6.1	1.0	...	...	0.0	...	...
Income adequacy quintile (Q)										
Q1 (lowest)	853	16.4	14.9	13.9	2.0	1.8	2.2	7.5	6.2	8.7
Q2	773	12.7	11.8	11	1.6	1.4	1.8	4.3	3.2	5.4
Q3	652	9.8	10.6	9.8	1.4	1.3	1.6	3.1	2.1	4.2
Q4	541	7.8	8.5	7.8	1.1	1.0	1.3	1.0	0.0	1.9
Q5 (highest)[1]	551	7.8	7.5	6.9	1.0	...	...	0.0	...	...
Occupation										
Managerial[1]	169	5.5	4.2	7.2	0.7	0.5	0.9	-2.7	-5.0	-0.4
Professional	106	8.3	6.6	10.3	1.0	...	...	0.0	...	...
Skilled/Technical/Supervisory	550	9	8.1	10	1.1	0.9	1.4	0.7	-1.3	2.8
Semi-skilled	569	9.6	8.6	10.7	1.2	0.9	1.5	1.3	-0.7	3.4
Unskilled	298	12.7	11.1	14.6	1.5	1.2	2.0	4.4	1.9	6.9
No occupation	1,678	12.7	11.8	13.6	1.5	1.2	1.9	4.4	2.4	6.4

[1] reference group (RR = 1.00 and RD = 0.0)
... not applicable
Notes: Reference populationfor age-standardization was from 1991 Canadian population. Because of small counts, other lung cancer histologies were excluded from analysis.
Source: 1991 Canadian Census Cohort: mortality and cancer follow-up.

for all three SES indicators. A negative gradient in the risk of adenocarcinoma was apparent for education and income, but no consistent association with occupation emerged. This is in line with research showing that the association with cigarette smoking (attributed to 85% to 90% of lung cancer cases[7,8,30,31]) prevails for all histological subtypes, but is strongest for squamous cell cancers and small-cell cancers, followed by adenocarcinoma.[32-34]

Strengths and limitations

A major strength of this study is the large, representative, population-based cohort that allows for the examination of several SES variables simultaneously.[21,22] The granularity of socioeconomic data available for the cohort makes it possible to explore individual-level data, in contrast to area-based measures that can mask inequalities evident at the individual level.[35] Because the sample size and the length of the follow-up period increase statistical power, cancers with long latency periods can be examined and analyses can be conducted by subgroup.

A limitation of the cohort is that it pertains only to people aged 25 or older, and excludes residents of institutions, people not enumerated by the 1991 Census long-form questionnaire and those who did not file taxes in 1990 or 1991.[21,22,25] As well, although the cohort is broadly representative of most groups in the Canadian population, some characteristics differ.[22,35] For example, owing to the nature of the linkage, the cohort under-represents rural residents (less precise postal codes for matching), people with less than secondary graduation (who are less likely to be employed), and people not in the labour force and those in the lowest income quintile (both groups are less likely to be tax-filers).[22,25] Moreover, the cohort was not disease-free at baseline, so some members may already have had underlying conditions that could have contributed to the risk of lung cancer.[21,22,25]

Another limitation is that SES characteristics were captured at a single point in time, which does not allow for examination of changes in exposures over time. As well, the dataset does not include important behavioural and environmental risk factors. Having data on key risk factors such as smoking and an extension of the follow-up period would make it possible to understand historical and birth cohort effects of smoking and their impact on lung cancer inequalities in the context of an evolving smoking epidemic in Canada.

An area for further research is the extent to which smoking and other risk factors may explain the SES gradient in lung cancer risk.[9,24,36] Previous studies indicate that adjusting for smoking can decrease SES differences in lung cancer risk by 50% to 65%, and that more complete adjustments for smoking can almost eliminate the association.[9,37] This suggests a potential for misclassification of lifetime exposure to tobacco due to the use of proxy subjects or self-reported behaviour (often captured at a single point in time) and broad risk categories (ex-/never-/current smokers), and to the challenges of measuring smoking intensity over time.[9,37] Occupational exposures can account for up to 14% of inequalities after adjustment for smoking and fruit and vegetable consumption.[36] Findings of the few studies on diet (fruit and vegetable consumption) are not consistent,[9] nor are studies of exposures such as radon in the home and air pollution, although it is possible that these risks may contribute to residual differences in lung cancer incidence.[12,13,31]

Conclusion

This large-scale, nationally representative cohort study showed a negative socioeconomic gradient in lung cancer incidence rates in both men and women. Inequalities in lung cancer risk were particularly pronounced for histologies more strongly associated with smoking. In the future, it will be important to explore the role of smoking, occupational exposures, and diet on lung cancer risk to understand the extent to which inequalities remain after adjustment for these known risk factors. Linkages of the 1991 Census Cohort to surveys such as the Canadian Community Health Survey or the Canadian Tobacco Use Monitoring Survey may be helpful in this respect. Extension of the follow-up period may allow for the study of cohort effects. ■

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Appendix

Appendix Table A
Cohort members and person years at risk (PYAR), by sex and selected socioeconomic status characteristics at baseline, Canada, 1991 to 2003

	Cohort members	PYAR
Men	1,358,226	18,969,038
Educational attainment		
Less than secondary graduation	474,860	6,249,271
Secondary graduation	510,401	7,319,210
At least some postsecondary	168,324	2,457,724
University degree	204,641	2,942,833
Income adequacy quintile		
Q1 (lowest)	197,324	2,555,443
Q2	260,751	3,500,066
Q3	287,736	4,077,332
Q4	302,556	4,359,268
Q5 (highest)	309,859	4,476,874
Occupation		
Managerial	158,928	2,622,613
Professional	145,983	1,847,991
Skilled/Technical/Supervisory	391,552	5,761,416
Semi-skilled	303,341	4,453,548
Unskilled	115,461	1,671,041
No occupation	242,961	2,616,185
Women	1,376,609	4,672,898
Educational attainment		
Less than secondary graduation	478,504	1,974,926
Secondary graduation	483,962	1,480,166
At least some postsecondary	253,026	795,804
University degree	161,117	422,002
Income adequacy quintile		
Q1 (lowest)	273,000	742,257
Q2	270,260	729,758
Q3	277,639	855,824
Q4	278,215	1,030,062
Q5 (highest)	277,495	1,314,997
Occupation		
Managerial	65,792	242,640
Professional	160,279	540,116
Skilled/Technical/Supervisory	260,053	907,484
Semi-skilled	360,574	1,278,859
Unskilled	100,597	420,082
No occupation	429,314	1,283,717

Source: 1991 Canadian Census Cohort: mortality and cancer follow-up.